A journey toward global value chain upgrading: Exploring the transition from backward to forward integration

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Abstract

Global value chains (GVCs) are embraced worldwide as a gateway to technological and economic upgrading. Countries integrate into backward, value-importing linkages with the aim of accumulating technological capabilities and transitioning towards creating their own forward, value-exporting chains while capturing a greater share of the value generated within GVCs. Existing knowledge, which is largely fragmented and descriptive, points to a number of uncertainties and complexities that make this process far from linear. It remains an open question whether deepening backward linkages facilitate forward integration in GVCs. Using data from 65 countries over two decades, we demonstrate that the impact of backward integration on forward integration in GVCs varies over time and is moderated by the country's level of development, the diversity of the GVC partner network, and the innovation conditions in the home market. The research introduces a new perspective to the literature on GVC-driven upgrading.

Keywords: global value chain, upgrading, backward and forward integration

JEL: F14, F6, O3

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1. Introduction

The fragmentation of the production process through global value chains (GVCs) enabled many nations to take advantage of the opportunities of globalisation by complementing traditional trade in goods with trade in values and tasks (Baldwin and Robert-Nicoud, 2014). Today, GVCs account for more than two-thirds of global trade (Kordalska and Olczyk, 2021) and contribute to about 5% of global output (Kummritz, 2016). In addition to their trade-augmenting feature, GVCs hold potential for knowledge and technology transfer (Tian et al., 2022), which makes them widely regarded as drivers of productivity and growth (Beverelli et al., 2019) in developed (Pleticha, 2021) and developing economies (Stollinger, 2016). At the same time, our knowledge about how nations integrate into GVCs and how they exploit their potential is still largely fragmented. Moreover, the anticipated positive effects seem to depend on a number of factors that are both internal (Gereffi et al., 2005) and external (Gereffi and Sturgeon, 2013) to GVCs.

The upgrading perspective of GVCs is based on the proposition that improving the quality and sophistication of exports leads to broader industrial upgrading and growth (Rodrik, 2006; Hausmann et al., 2007; Amiti and Khandelwal, 2013; Henn et al., 2020). This occurs through a cumulative learning process (Nelson and Winter, 1982) that involves interactions among actors in innovation systems (Lundvall and Johnson, 1994). From there, GVCs facilitate upgrading of nations in at least two ways, by creating opportunities for the use of domestic resources in exploring technological frontiers (Tian et al., 2022) and by complementing domestic capabilities with knowledge and technology that are lacking in the domestic market (Ndubuisi and Owusu, 2021). Mastering certain value chain functions within such a framework serves a dual purpose: as a current source of competitiveness, and as a foundation for later learning and accumulation of more sophisticated skills needed in more value-intensive GVC segments (Mehta, 2022).

While the above discussion might lead to the conclusion that upgrading within GVCs is linear, in reality this process is uncertain, complex and fraught with numerous obstacles and detours (Lee, 2019). The possibilities for upgrading depend on the power asymmetries within GVCs, the absorptive capacity of the actors involved and the durability of their relationships (Hobday, 1995), and the institutional conditions and policies of their home market (Gereffi and Sturgeon, 2013). If these factors are not aligned in a way that facilitates the flow of knowledge and

technology, nations may remain trapped in existing GVC levels with limited opportunities for further upgrading (Pietrobelli and Rabellotti, 2011). More importantly, different GVC functions require different types of knowledge (Mehta, 2022), which are not always found within the existing pattern of integration. This suggests that at a certain point of upgrading, further learning requires a change in the GVC integration pattern (Mehta, 2022).

The above discussion forms the basis for examining how nations transition from one GVC integration pattern to another. Broadly speaking, countries can participate in GVCs either through backward linkages as predominant importers of value or through forward linkages in which they export value (Pietrobelli & Rabellotti, 2011; Ge et al., 2018; Nadeem et al., 2021). The two patterns differ in the ratio of domestic to foreign value added embodied in the products, but also in the extent of learning potential. While backward linkages promote functional and sectoral learning (Lee et al., 2018) and process complexity (Gal and Witheridge, 2019), the R&D, design or marketing functions that are essential for product sophistication and pushing technological frontiers are more typical of forward integration GVCs (Antras, 2020; Bontadini et al., 2021). Previous studies have pointed to the upper limits of learning through backward GVCs and the need to reduce dependence on imported values (Lee et al., 2018), but they offer little evidence of the impact of backward integration on the ability to increase the intensity of forward integration (Mehta, 2022).

Current knowledge on GVCs is at a stage where the above issues are discussed theoretically but lack empirical confirmation. Lee et al. (2018) suggest that backward integration offers diminishing returns to learning and eventually requires nations to reduce their dependence on imported value and to rely on their own strengths. Mehta (2022) is, as far as we know, the only study to examine the upgrading from backward to forward integration of GVCs, but even their analysis is descriptive and limited to the electronics industries in South Korea, Taiwan and Mexico. Anecdotal and descriptive evidence from different parts of the world (Hobday, 1995; Wang et al., 2014; Radosevic and Yoruk, 2016) shows that reaching the technological frontier requires nations to leave backward-integrated GVCs and build their own forward-integrated GVCs. However, none of the existing studies provides a clear answer to the question of whether being part of backward GVCs actually leads to forward integration.

The above gap is not negligible, as GVC-driven upgrading is a subject of debate and concern in both developed and developing countries (Tian et al., 2022). Broadly speaking, nations enter

GVCs with the long-term goal of establishing their own forward oriented,value chains and capturing larger share of the returns generated within the GVC (Lee et al., 2018). Backward linkages can be a first step on this path, but in many developing countries they have led to captive relationships at the GVC level with little domestic value added and limited opportunities for upgrading and growth (Baldwin and Robert-Nicoud, 2014; Lee et al., 2018). At the other end of the spectrum, there are concerns that technology and knowledge transfers contribute to competitors acquiring sophisticated skills and technologies, effectively worsening the competitive advantage of forward-integrating developed countries (Rodriguez-Clare, 2010; Li and Liu, 2014). These negative effects are the reason for scepticism about the future of GVC-led upgrading and call for an examination of the transition between GVC integration patterns.

Against this background, our study aims to investigate whether the backward integration of nations helps to strengthen their forward integration in GVCs. We draw on data from 36 industries in 65 countries over a period of more than two decades (1996-2018) and complement Lee et al. (2018) and Mehta (2002) in defining upgrading as the process of transition from backward to forward GVC integration. Given the critical importance of institutions for GVC integration outcomes (Adarov and Stehrer, 2021), we model the transition between GVC patterns as a continuous process of interaction and co-evolution among the actors involved in the institutional context (Mehta, 2022). The results, which are robust to the use of different estimation techniques, show differential effects of backward to forward integration over time, moderated by the level of development, the diversity of the partner network and home market conditions. Overall, the results offer evidence-based recommendations for those interested in GVC-driven upgrading.

The analysis makes several contributions. We extend previous knowledge on industrial upgrading in the context of globalisation and transnational production linkages. In particular, we fill the gap in the literature on GVC-driven upgrading (Jangam and Rath, 2020; Ndubuisi and Owusu, 2021; Mehta, 2022; Tian et al., 2022) by providing for the first time a quantitative assessment of the relationship between backward and forward integration patterns. Second, we respond to recent calls for a new way of thinking about and formulating industrial policy in the era of GVC expansion (Hauge, 2020) by assessing the moderating effects of development level, home market conditions and partner diversity on the transition between GVC integration patterns over time. Third, our research responds to the call for integrating different theoretical

approaches to explain GVC-driven upgrading (Lee et al., 2018) by merging theses from export-oriented models with those from evolutionary and systemic innovation theories.

The paper is structured as follows. The next section provides a conceptual framework and hypotheses. The characteristics of the dataset are presented in section three. The model and methodology are presented in section four. Section five presents and discusses the empirical results. Concluding remarks are given in section six.

2. Conceptual framework

2.1. Trade in value added, technological upgrading and growth

As mentioned in the previous section, countries integrate into GVCs with the aim of accumulating capabilities required for the pursuit of technological frontiers and capturing a greater share of value-added (Lee et al., 2018). Individual theories have attempted to explain fragments of this process, but its totality cannot be understood without integrating at least three theoretical currents. The first of these streams, the export-led growth models (Rodrik, 2006; Hausmann et al., 2007), assume that technological upgrading exports is key to national competitiveness (Jangam and Rath, 2020) and call for investment in learning relevant to the shift to higher value-added products and more rewarding functional positions within the production value chain. The other two, the evolutionary models of upgrading (Nelson and Winter, 1982) and the innovation systems literature (Lundvall, 1992; Lundvall and Johnson, 1994), focus more on the nature of the learning required for technological upgrading and the mechanisms through which it occurs.

According to the evolutionary perspective (Nelson and Winter, 1982), learning is a cumulative process in which new knowledge emerges on the shoulders of previously acquired skills. The lessons learned through trial and error in imitation, experimentation and exploration enable economic systems to evolve into increasingly sophisticated products, processes and production functions, ultimately improving their competitiveness. Systems of innovation models (Lundvall and Johnson, 1994) extend this framework by pointing to the importance of interactions between economic agents such as firms, industries or institutions for the flow of knowledge and technology that leads to the accumulation of capabilities. Taken together, the theoretical tripod of export-oriented, evolutionary and systems of innovations propositions suggests that interactions between actors in the production chain facilitate the learning and

accumulation of knowledge and technology required to achieve more sophisticated levels of production and exports relevant for higher growth rates and competitiveness.

At the intersection of these three theoretical frameworks, cross-border fragmentation of production processes emerges as a pathway to technological and economic upgrading (Gereffi, 1996; Henderson et al., 2002; Bilbao-Ubillos and Camino-Beldarrain, 2021; Ndubuisi and Owusu, 2021,). In recent decades, GVCs have gained a reputation as platforms for experiential learning and export-driven knowledge acquisition (Baldwin and Robert-Nicoud, 2014; Beverelli et al., 2019; Tian et al., 2022). Trade in value added within GVCs has been found to facilitate technology transfer, knowledge spillovers and access to more affordable and higher-value intermediates (Ndubuisi and Owusu, 2021). Participation in GVCs enables countries to benefit from product, process and functional upgrading (Pietrobelli and Rabellotti, 2011). Consequently, GVC integration has emerged as a strategy for nations to improve their competitiveness in an increasingly interconnected global landscape (Kaplinsky and Morris, 2002; Pietrobelli and Rabellotti, 2011; Javorcik, 2015; Pahl and Timmer, 2020; Fridell and Walker, 2019).

The above theoretical claims have been supported by empirical evidence of productivity spillovers (Carballa Smichowski et al., 2021) and learning (Kummritz, 2016) within GVCs that have contributed to industrial upgrading (Tian et al., 2022) and the quality of exported products (Ndubuisi and Owusu, 2021). However, many aspects of GVC integration remain unexplained (Beverelli et al., 2019). In particular, there is a lack of knowledge on the relationship between GVC integration patterns in upgrading of countries at different stages of development (Tian et al., 2022), over time (Rodriguez-Clare, 2010; Lee and Malerba, 2017), in relation to the structuring of GVC networks (Gereffi et al., 2005) and in relation to domestic absorptive capacity (Ge et al., 2018). This calls for further research that would shed light on the process of technological upgrading within GVCs.

2.2. Upgrading trajectories within GVC integration patterns

The integration of nations into GVCs takes the form of two patterns known as backward and forward linkages. The former refers to participation in GVCs where imported value added is included in domestic exports. The latter includes cases where domestic value added is exported and embedded in products exported by other GVC members. These two patterns differ in the

nature of the tasks performed and the knowledge and value added they contain (Hobday, 2003; Grossman and Rossi-Hansberg, 2008; Antras, 2020). It is important to understand this distinction as it determines the scope of each pattern for technological and economic upgrading.

The systems of innovation distinguish broadly among four dimensions of knowledge (Lundvall and Johnson, 1994). The first two of these dimensions answer the questions of what and why and refer to factual and scientific knowledge that can be easily articulated, replicated and disseminated or adopted. The other two types of knowledge answer the who and how questions. They are more specific and difficult to identify and absorb because they relate to social relationships, which are the essential aspect of knowledge transmission, and to multifaceted capabilities required to perform tasks and pursue change in the growth process (Mehta, 2022). Although certain facets of this knowledge can be easily transferred in tangible forms such as machines or equipment, most of it remains tacit and its successful acquisition and use depends on the absorptive capacity of the recipients.

At different stages of GVC integration, these four types of knowledge provide diverse upgrading opportunities (Javorcik, 2004; Havranek and Irsova, 2011; Kummritz et al., 2017). While the skills required to perform standardised low value-added tasks can be mastered through interaction with knowledge embodied in imported technology and through the assembly of semi-finished products, mastering more complex skills requires exposure to cutting-edge technologies and advanced manufacturing techniques through the production of sophisticated products, exploration and interaction within the GVC (Mehta, 2022). A number of barriers on both the receiving and sending sides of this process can stand in the way of upgrading, such as capability gaps (McDermott and Pietrobelli, 2018) and hierarchical barriers that permeate upgrading within GVCs (Kergroach, 2019). These barriers limit a nation's ability to move beyond low-value-added activities (Stollinger, 2016) to the next stage of upgrading (Engel and Taglioni, 2017; Nadeem et al., 2021) and can trap them in the middle-income trap (Gill and Kharas, 2015).

The role of hierarchical barriers is particularly relevant in the context of GVC-driven upgrading. Lee et al. (2018) find that incentives for knowledge and technology transfers through backward linkages decline as countries at the receiving end of GVCs approach high levels of technological development. Tian et al. (2022) attribute this phenomenon to the reluctance of technologically superior GVC members to disclose and transfer knowledge and

technology behind their key competitive advantages. This suggests that at a certain stage of upgrading nations may attempt to move from existing backward linkages characterised by the import of value to a forward GVC pattern characterised by the export of value (Hobday, 2003; Lee and Malerba, 2017; Mehta, 2022).

2.3. GVC-driven upgrading and the role of home market conditions

GVCs are prone to captive relationships (Gereffi et al., 2005) and complex transactions (McDermott and Pietrobelli, 2017), which can act as barriers to knowledge and technology transfer. Efficient institutional frameworks reduce such barriers (Lundvall, 1992; Morrison et al., 2008; Stollinger, 2016; Nadeem et al., 2021; Pleticha, 2021) by shaping the incentives, rules and infrastructure relevant to upgrading. To this end, institutions enhance the capacity of nations to take advantage of the opportunities for learning and skill acquisition provided by GVCs (Pietrobelli and Rabelloti, 2011; Ndubuisi and Owusu, 2021). They promote interaction between global and local actors, reduce the negative effects of power asymmetries and resolve conflicts of interest between stakeholders. In addition, interventions in education, infrastructure, finance and labour markets can influence the transition to higher value-added GVC segments (Gereffi and Sturgeon, 2013; Ge et al., 2018; Antras, 2020).

In this framework, institutional advances contribute to the learning process by creating conditions for the accumulation of technological capabilities (Kummritz et al., 2017; Ge et al., 2020). They promote quality education and skills development, enable enterprises to access financial resources, and balance labour force protection with flexibility to adapt to market dynamics and technological advances. Sustainable learning requires domestic investment in a knowledge infrastructure that can effectively translate external knowledge into domestic technological capabilities (Mehta, 2022). Similarly, the ability to develop effective protection of intellectual property rights can help the country improve its status within the value chain by relieving technologically superior GVC members of the fear of infringing strategic intangible assets (Yang et al., 2020). The quality of the institutional framework, innovation system and IPR protection becomes particularly relevant in situations where upgrading by backward GVCs no longer yields substantial gains (Cirrera and Maloney, 2017; McDermott and Pietrobelli, 2017; Hu et. al., 2022) and forces countries to shift to forward GVCs (Lee, 2019).

While some recent studies have begun to shed light on this aspect, existing knowledge is still largely fragmented. Kummritz et al. (2017) and Jangam and Rath (2020) have highlighted the role of policy in inputs, outputs, investment, business climate, and financial and labour market institutions in upgrading through GVCs. Nadeem et al. (2021) argue that the effectiveness of domestic institutions contributes to the positive impact of GVCs on economic growth, while Lee et al. (2018) show the importance of local innovation systems in the upgrading process driven by participation in GVCs. However, these studies have typically assessed capability accumulation and upgrading through backward or forward patterns in isolation, without considering their interconnectedness and the impact of institutions on the transition between these two patterns of integration.

2.4 Hypotheses development

The discussion so far points to the diverse roles of each integration pattern in the process of capability accumulation and upgrading. Previous studies have pointed to the upper limits of upgrading through backward GVCs (Ndubuisi and Owusu, 2021) and the advantages of forward GVCs in proximity of the technological frontier (Jangam and Rath, 2020). Based on the proposition that nations join GVCs with the long-term goal of building and upgrading own forward oriented value chains and syphoning off a greater share of the profits generated within GVCs (Lee and Malerba, 2017), the question is whether backward integration helps nations achieve this goal. In traditional GVC models, upgrading is modelled as a function of deepening integration within existing GVCs, as these models are mainly static and assume that there are no changes in the GVC hierarchy. The alternative catch-up cycle perspective (Lee and Malerba, 2017) suggests that the combination of barriers to further upgrading through backward linkages and domestically accumulated capabilities should incentivise nations to reduce their dependence on imported values and shift to forward, value-exporting, value chains.

With the partial exception of work on the in-out-in hypothesis (Lee et al., 2018; Lee, 2019), the systematic framework of relationships between GVC integration patterns has not yet been addressed. A recent conceptual framework (Mehta, 2022), anchored in the evolutionary (Nelson and Winter, 1982) and SI literature (Lundvall, 1992), attempts to fill this gap by presenting upgrading within GVCs as a four-step process in which higher levels of productivity require the transition from backward to forward GVC integration patterns. Within the above framework, the journey of nations towards upgrading starts with backward GVC integration

(Hobday, 1995; Wang et al., 2014), where countries interact with imported technologies and gradually move from simple activities to more complex and sophisticated production tasks to the production of standardised products. Learning in this phase is mainly limited to reverse engineering, learning-by-doing or learning-by-use and refers to skills required to use imported technologies and production-related skills.

In some cases, backward integration can lead to experimentation with innovations to increase the efficiency of the production process (Pietrobelli and Rabellotti, 2011). In many other cases, knowledge transfer from technologically superior members to their upgrading counterparts has a diminishing character and remains limited to production-related knowledge (Gereffi et al., 2005; Lee et al., 2018; Lee, 2019). Combined with weaknesses in domestic institutions and innovation systems, this can lead to entrenchment in low value-added GVC segments with limited upgrading. The lack of further upgrading opportunities requires countries to reassess their situation and shift towards building their own value chains, relocating low value-added tasks to low-cost locations, and using domestic resources to produce sophisticated and complex products at the technological frontier (Lee et al., 2018). Once this stage is reached, countries can continue upgrading through the deployment of domestic resources in research and development and pursuing innovation in synergy with national and sectoral innovation systems.

In summary, we argue that backward GVC integration provides the opportunity to adopt and use external knowledge, but the transformation of this knowledge and the creation of new knowledge requires a shift to a forward GVC pattern at some point. This is because backward-looking GVCs support the development of production-related capabilities through the adoption of quality standards, improved production efficiency (Jangam, 2021; Jangam and Rath, 2021) and access to a wider range of better quality or lower cost inputs (Gal and Witheridge, 2019). The additional benefits arising from backward GVCs tend to diminish as countries move to more advanced stages of GVC participation, characterised by high value-added tasks and products that require sophisticated innovation capabilities (Blažek, 2016; Lee et al., 2018; Pahl and Timmer, 2020). In these stages, forward integration offers greater advantages for the upgrading process, as it allows countries to allocate a larger share of their resources to innovation activities (Pan, 2020; Bontadini et al., 2021).

H1: The degree of backward integration in GVCs has a positive influence on the degree of forward integration in GVCs.

Evolutionary models of learning (Nelson and Winter, 1982; Dosi and Nelson, 2016) assume that upgrading is not the result of immediate, isolated decisions, but rather the result of continuous, strategic and future-oriented explorations and learning from past experiences. Historical accounts of the paths that East Asian (Hobday, 1995; Lee, 2013), Central European (Radosevic and Yoruk, 2016) and Central American (Mehta, 2022) economies have taken over time show that the journey from experimenting with standardised technologies to mastering complex tasks and producing sophisticated products can take several decades, and that considerable time can pass before nations move from one functional stage of GVC integration to the next. Lee and Malerba (2017) support these claims by citing evidence of the time it has taken to build capabilities in a range of industries around the world.

The GVC literature acknowledges the cumulative nature of learning, pointing out that sophisticated and complex tasks and products require the accumulation of applied and experiential knowledge over time (McDermott and Pietrobelli, 2017; Tian et al., 2022), although it does not explicitly address the underlying theoretical mechanisms (Carballa Smichowski et al., 2021). Time is also important for skill accumulation from the perspective of SI as it forms the basis for the development of the social relationships required for the flow of knowledge and technology (Lundvall and Johnson, 1994). The interactive and cumulative nature of knowledge accumulation requires that participants are able to identify counterparties with the right knowledge and skills, which helps to reduce uncertainty about market trends and technological opportunities (Mehta, 2022). In addition, knowledge flows can be facilitated in times of uncertainty based on respect, trust and friendship, characteristics of social relationships that only develop over time.

Overall, it can be said that nations have a short-term incentive to upgrade through backward GVCs, as they can learn how to use imported knowledge and technologies. The social relationships that develop during this period will provide knowledge about markets that can help predict market trends and reduce the risk of failure in subsequent upgrading, while facilitating the transfer of knowledge and technology. Similarly, the accumulated knowledge will serve as a basis for further learning (Hobday, 1995). However, as time passes and capabilities for the most complex tasks and sophisticated products increase, the efforts of those at the upper levels of GVCs to protect their core competitive advantages will increase, reducing

the gains from further backward integration (Lee and Malerba, 2017). Subsequent upgrading then takes the form of functional and product upgrading and requires the formation of forward GVCs where accumulated capabilities can be used in the pursuit of innovation and knowledge-intensive products (Lee et al., 2018).

H2: Backward GVC integration has a negative effect on forward GVC integration in the short run but a positive effect in the long run.

One of the unresolved issues in GVC-driven upgrading concerns the differential impact of GVC participation on developed and developing countries (Kummritz et al., 2017; Tian et al., 2022). On the one hand, participation in GVCs enables the reallocation of resources to more sophisticated tasks and products (Baldwin and Robert-Nicoud, 2014), giving developed countries access to cheaper intermediate goods while freeing up resources that can be channelled into the execution of complex tasks and the production of high value-added products. While upgrading, especially in the context of backward integration and simpler, low value-added tasks, developing countries are deprived of the opportunity to develop to the level of developed economies over an extended period of time (Tian et al., 2022). Another view is that GVC integration facilitates the transfer of knowledge and technology from developed to developing countries, which in turn enables the upgrading of the latter (Li and Liu, 2014).

Each perspective has opposing views. Developing countries may remain trapped in low value-added GVC segments with limited potential for upgrading (Gereffi et al., 2005), while critics of GVC integration in developed countries point to the loss of competitive advantage through the redistribution of technological capabilities in developing countries that enable them to improve their own efficiency and learn how to leverage existing and new knowledge through the use of and interaction with imported technologies (Li and Liu, 2014). The cyclical nature of this process means that developing countries are accumulating increasingly sophisticated capabilities that, in an optimistic scenario, should bring them to a technological level comparable to that of their developed counterparts (Tian et al., 2022).

Whether GVC integration has stronger effects on upgrading in developed or developing economies is an open question, but for several reasons it can be argued that this effect will be stronger in developed countries. First, importing value via backward GVCs in developing countries provides incentives for forward integration only up to a certain point. Beyond this

threshold, countries may be trapped in low value-added activities with deeper backward integration, which offer limited potential for the accumulation of capabilities needed to compete at the technological frontier. Second, backward integration serves a different purpose in developed countries than in their developing counterparts. In particular, it serves as a source of affordable intermediates that enable the use of domestic resources in innovation activities. This facilitates the development of domestic value chains (Beverelli et al., 2019) and the integration of these countries into GVCs through forward integration. As a result, the positive effect of backward-to-forward GVCs is expected to be stronger in developed countries.

H3: A higher level of development of a country positively moderates the relationship between backward and forward GVC integration.

The literature often highlights the risks of captivity within GVCs (Gereffi et al., 2005), a situation in which hierarchical barriers hinder knowledge and technology transfer between GVC leaders and their followers. Evidence of barriers to knowledge transfer in such circumstances has been found in Latin America (McDermott and Pietrobelli, 2017), Central and Eastern Europe (Sass and Szalavetz, 2014; Stojcic, 2021) and East Asia (Lee et al., 2018; Lee, 2019). In this context, there is a growing emphasis on the importance of building local and regional value chains through which GVC reconstruction takes place (Song et al. 2021). But even more important is the question of whether it is more opportune for a country to anchor itself in one or more GVCs. On the one hand, a narrower GVC network offers more room for specialisation and the strengthening of relationships between participating actors, but also carries the risk of the aforementioned captivity. On the other hand, diversified GVC integration across multiple chains can offset the risk of captivity, especially in the case of chains that are geographically more distant and therefore do not compete directly with each other. This allows us to formulate our fourth hypothesis.

H4: GVC network diversification positively moderates the effect of backward on forward GVC integration

GVCs provide opportunities for knowledge and technology transfer (Pietrobelli and Rabellotti, 2011), but the ability to benefit from these transfers and to advance within existing value chains and develop new ones depends on the strength of the domestic science and technology environment (Cohen and Levintahl, 1990; Kergroach, 2019; Bilbao-Ubillos and Camino-Beldarrain, 2021). Well-developed innovation systems reduce costs and transaction barriers (Pietrobelli and Rabellotti, 2011; Sass and Szalavetz, 2014), enabling functional upgrading and

the formation of domestic value chains. Research suggests that a certain level of R&D capacity is required to acquire advanced technologies and benefit from technology spillovers within GVCs (Ge et al., 2018). The development of private and public R&D institutions is critical to building advanced R&D capacity (Nelson, 1993), but many countries entering GVCs have weak science and technology infrastructure and limited links to the local business sector (McDermott and Pietrobelli, 2017). Therefore, the effects of backward GVC participation may be facilitated by domestic R&D efforts.

H5: Domestic investment in R&D activities positively moderates the effect of backward on forward GVC integration

3. Data and methods

Our main dataset is the Trade in Value Added (TiVA) database (OECD, 2021). We use the latest version from 2021, covering 36 ISIC rev.4. industry sectors from 35 developed and 30 developing countries over the period 1996-2018, to calculate indices of backward and forward integration of GVCs. Following the approach often used in the literature (Koopman et al., 2014), the indices of backward and forward integration of GVCs are calculated for each country-sector pair as the share of foreign value added in domestic exports and the share of domestic value added in exports of other economies in the world, respectively, with both variables expressed as percentages. The resulting dataset covers all economic sectors for which data were available. We follow the GVC literature, which states that business functions other than manufacturing can be split up and carried out in geographically dispersed locations (Sass and Szalavetz, 2014).

The Worldwide Governance Indicators (WGI) database provided by the World Bank is used as a source of information on institutional quality. Specifically, we use data on (i) voice and accountability, (ii) political stability and absence of violence/terrorism, (iii) government effectiveness, (iv) regulatory quality, (v) rule of law, and (vi) control of corruption. Each of these indicators reflects the quality of the institutional framework as perceived by businesses, citizens and experts in the countries analysed. Next, each measure is constructed through a process that involves mapping data from individual sources to the six aggregated indicators, rescaling the data from each source to a value between 0 and 1, and finally using a model with unobserved components to construct a weighted average of the individual indicators for each source. The resulting indices follow a standard normal distribution with a mean of zero, a

standard deviation of one and a range between -2.5 and 2.5, with higher values reflecting better institutional quality.

The individual institutional variables are known for their high correlation, which prevents their joint inclusion in a single model. Our correlation matrix (Table A1 in the Appendix) confirms this. To address this problem, we conducted a principal components factor analysis with varimax rotation and Kaiser normalisation. This procedure yielded a single factor explaining 86% of the variance in the underlying variables. Table A2 in the Appendix provides details of the factor loadings, Kaiser-Meyer-Olkin and Bartlett tests that support our model. The importance of the institutional environment is discussed in detail in section 2.3. As mentioned there, the "core" dimensions of the institutional setting described above are particularly important for the upgrading process, as they ensure contract enforcement, lower transaction costs and reduced risks and uncertainties in doing business. They have also proven helpful in mitigating the risks associated with entering into GVC relationships.

Our third and final data source relates to innovation infrastructure, which is measured by the share of national GDP spent on research and development and comes from the World Bank's World Development Indicators database. Since we are unable to consider detailed innovation measures in such a large number of countries over such a long period of time as the one used in this analysis, we have to rely on the national share of R&D expenditure in GDP as a proxy for these factors.

The TiVA dataset contains 45,604 observations over the period 1996-2018, with country-industry pairs ranging from 2268 to 2286 over the years. However, the latter two datasets, World Governance Indicators and World Development Indicators, do not contain information for all countries included in the TiVA dataset. The result is a dataset with 36,757 observations and 2258 cross-sectional groups with an average number of 16 observations per cross-sectional group. We examined the potential for multicollinearity between the included variables. Table A3 in the Appendix shows that the variance inflation factors (VIFs) for all variables are between 1 and 2, with a mean VIF value of 1.4, indicating that multicollinearity is unlikely to be a problem in our dataset. With this in mind, we develop an empirical model that defines forward GVC integration as a function of backward GVC integration, innovation infrastructure and institutional setting. In general, the model can be expressed as follows:

$$forward_{ijt} = \alpha_0 + \beta_1 backward_{ijt} + \sum_{k=1}^{n} \gamma_k Z_{jt} + v_{it} \quad (1)$$

where *forward* refers to the forward GVC participation of industry *i* from country *j* in period *t*, *backward* measures the backward GVC participation of industry *i* from country *j* in period *t* and *Z* is set of control variables while v_{it} are idiosyncratic errors. The model also includes categorical (dummy) variables for country, industry and year specific effects in order to account for observation specific shocks coming from that source. Moreover, in subsequent steps of analysis we expand model (1) with measure of concentration of backward GVC partners. Table 1 provides definitions of variables.

Table 1: Description of variables

Variable	Definition	Min	Max	Mean	Std.dev
forward	Share of domestic value added from industry *i* embodied in exports of other countries (in %)	0	2.87	0.03	0.10
backward	Share of foreign value embodied in exports of industry *i* (in %)	0	90.66	21.54	14.33
R&D	R&D expenditure as % of GDP in country *j*	0.02	4.94	1.37	0.99
institutions	Aggregate index of institutional quality	-2.87	1.55	0	1
concentration	Herfindhal-Hirschmann index of partner shares in foreign value added embodied in domestic exports	0	100	20.05	11.86

The longitudinal nature of our data set makes panel estimation procedures a logical methodological choice. Due to the temporal dimension of 20 years, methods such as dynamic panel analysis developed for datasets with large N and small T dimensions are not feasible. Moreover, our analysis combines industry- and country-level variables that need to be taken into account in the estimation. At the same time, the observed phenomena may be subject to universal cross-sectional shocks. This suggests that a single method of analysis is unlikely to provide comprehensive survey results. We therefore resort to an alternative strategy and assess the robustness of our results using several methodological approaches. We use a static panel analysis with random effects as a baseline model. However, random effects estimations rely on a strict exogeneity assumption that requires researchers to include all relevant variables in the model. Although our model includes all variables available for a sample as large as the one used here, the estimation should be carried out with the above considerations in mind. We use robust standard errors.

The analysis includes independent variables at different levels of aggregation. In particular, we include the GVC integration variables at the country-industry level and several other control variables at the country level. The sample consists of heterogeneous groups of industries and countries. For this reason, there may be variations in country- and industry-level intercepts and country-level slopes that affect our estimates. To control for the possibility that subjects within the same cluster are correlated due to common random intercepts or slopes, we use mixed effects estimation. Specifically, we use a three-stage modelling strategy with variations in country-level and industry-level intercepts and country-level slopes with respect to each of the country-level variables.

We also use a least squares regression with dummy variables to test the validity of our results in the presence of explicit controls for the fixed effects. Finally, we use a linear regression with double selection lasso. The use of a machine learning technique such as Lasso focuses on the key variables of interest, in our case backward integration, and selects one from the pool of available control variables. The double selection machine learning algorithm is specified to be robust to model selection errors. By using the plug-in method, Lasso estimation with double selection has properties for large samples (Belloni et al., 2012 and 2016) and can be used for inference on the causal parameters. The advantage of this method over others is that it restricts the selection of potential covariates and their interactions to those that are important for estimation.

5. Empirical analysis

The analysis starts with a baseline specification and continues with further developments where we examine the impact of time lags, level of development, interaction with home market innovation potential and diversification of GVC sources. The results of the investigation in Table 2 offer initial insights into our research question. We observe a negative and statistically significant effect of backward GVC integration on forward GVC integration that is robust across all estimation procedures. There are several explanations for this result. On the one hand, greater reliance on backward linkages among developing countries increases the risk of being trapped in the low value-added segments of the value chain (Gereffi et al., 2005). On the other hand, greater backward integration of developed economies may lead to resource allocation away from their traditional competitive advantages in high value-added activities. When

interpreting these results, it is also important to keep in mind that they reflect the relationship between two patterns of integration observed at same time. In such a short-term context, increasing backward integration typically provides limited opportunities for upgrading and is limited to specialisation in the lower value-added segments of the GVC (Mehta, 2022). The magnitude of the results deserves additional comment. The impact of the domestic institutional framework and domestic investment in R&D is several times higher than that of backward GVC integration. In this part, our results complement the thesis of Lee et al. (2018) that domestic accumulation of capabilities has a stronger impact on the ability of nations to build their own forward-integrated value chains than the intensity of backward integration.

Table 2: Results of baseline estimations

Variables	RE	ME	LSDV	Lasso ML
backward	-0.0005*** (0.00001)	-0.0004*** (0.0004)	-0.001*** (0.0001)	-0.001*** (0.0001)
R&D	0.01*** (0.0001)	0.01*** (0.0008)	0.01*** (0.002)	-
institutions	0.01*** (0.001)	0.02*** (0.004)	0.01** (0.004)	-
Country	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Groups	2258	2258	2258	2258
Obs	36757	36757	36757	36757

Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels respectively. Standard errors in brackets.
Source: Authors calculations

To explore whether these results hold across different moderating effects, we introduce several specifications that augment our model with interaction terms. Table 3 provides results of these estimations with two-way and three-way interactions which allow us to calculate marginal effects of variables for which we expect moderating effects and also to assess the equality of margins across different values of these variables. First specification introduces moderating effect of level of development of country. From there we extend model with moderating effects of home market innovation investment (model 2) and of partner network diversity or concentration (model 3). Important finding from Table 3 is that key interaction terms of interest are statistically significant as well as estimates of direct effects of each of analysed variables.

Table 3: Results from augmented models with interaction terms

Variables	(1)	(2)	(3)
backward	-0.0001**	0.0004***	-0.0002***

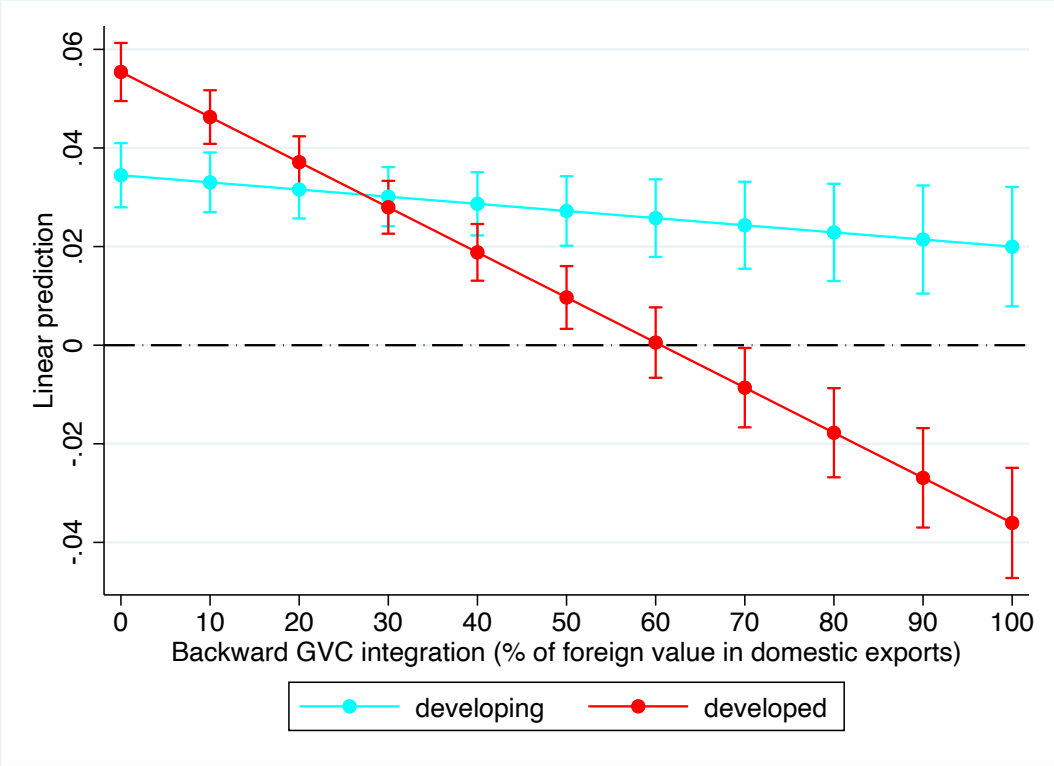
	(0.0001)	(0.0001)	(0.0001)
advanced	0.02*** (0.005)	0.06*** (0.005)	0.01*** (0.005)
R&D	0.01*** (0.001)	0.07*** (0.002)	0.01*** (0.001)
institutions	0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.001)
backward*advanced	-0.001*** (0.0001)	-0.001*** (0.0001)	-0.001*** (0.0001)
R&D*advanced	-	-0.06*** (0.003)	-
backward*R&D	-	-0.001*** (0.0001)	-
backward*R&D*advanced	-	0.001*** (0.0001)	-
concentration			-0.0002** (0.0001)
concentration*advanced			0.0005*** (0.0001)
backward*concentration			0.000006 (0.000004)
backward*concentration*advanced			0.00001** (0.000005)
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Groups	2258	2258	2258
Obs	36757	36757	36757

Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels respectively. Standard errors in brackets.
Source: Authors calculations

Figure 1 shows the marginal effects of the extended model (1), which only takes into account the moderating effect of the level of development. It clearly shows that the level of development moderates the relationship between backward and forward GVC integration. Although the effect decreases in both country groups as the intensity of backward integration increases, the magnitudes of the two effects and the direction are different. In the developing country group, the effect is positive but decreasing across all levels of backward integration. This is consistent with the claim that backward GVC integration provides greatest possibilities for upgrading at its lowest levels(Ndubuisi and Owusu, 2021; Tian et al., 2022). The results for developed economies show a different pattern. First, we observe a stronger and positive effect in this group of countries, most likely reflecting the positive impact of affordable imported intermediaries. However, this effect declines much faster and becomes negative once the share of foreign value added in domestic exports exceeds the 60% threshold. These results seem to be close to the offshoring critique (Samuelson, 2004; Kummritz, 2016), according to which

trade in tasks leads to the loss of competitive advantage in activities on which developed economies traditionally base their competitiveness.

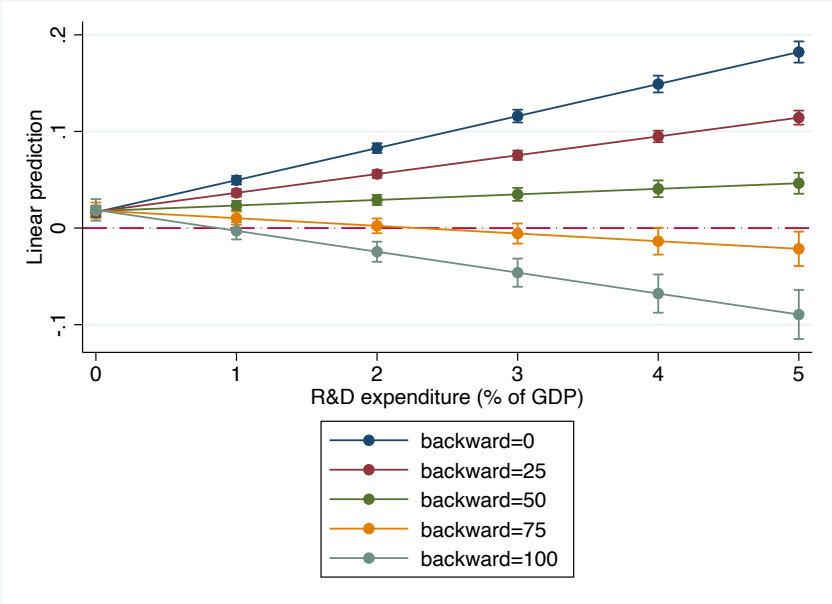
Figure 1: Moderating effect of level of development



Source: Authors calculations

Next, we examine how domestic investment in R&D affects the relationship between backward and forward GVC integration across the entire sample and between developed and developing economies. Figure 2 shows the marginal effects resulting from model (2) in Table 3. It indicates that the combination of GVC learning opportunities and domestic efforts to develop innovation infrastructure increases the chances of a shift from backward to forward GVCs and that this effect is stronger in developed economies.. It is evident that the effects are strongest when higher domestic investment in R&D is combined with lower backward GVC integration, with shares of foreign value added in domestic exports below 50%.

Figure 2: The moderating effect of domestic R&D expenditure



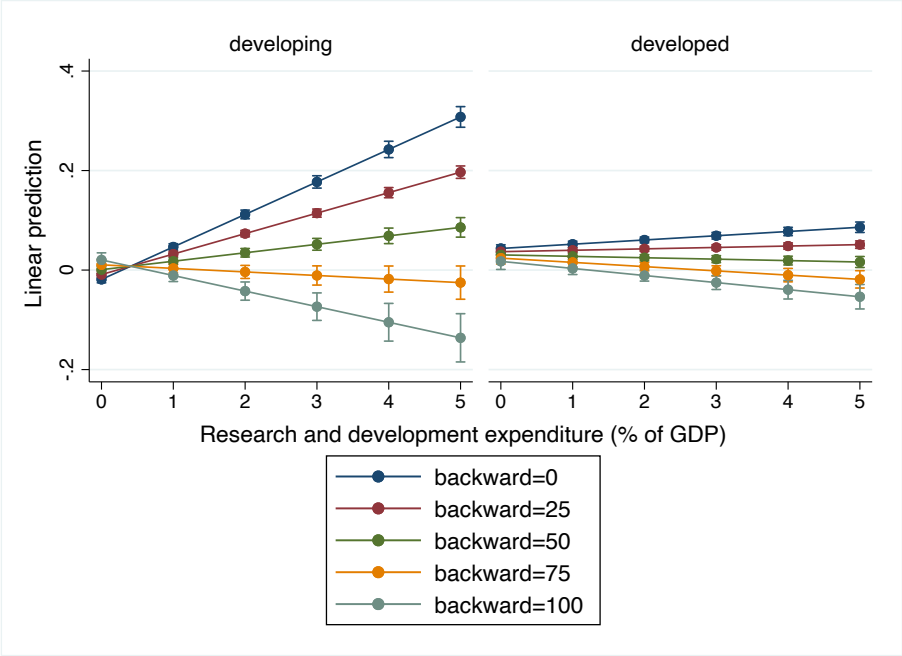
Source: Authors calculations

The above results are fully consistent with arguments from the previous literature on the upper limits of backward GVC upgrading and the need for nations to place more emphasis on domestic accumulation of capabilities (Lee et al., 2018). Accordingly, a higher degree of backward GVC integration carries a higher risk of captivity and offers more limited learning opportunities due to fear of technologically advanced GVC members over losing their competitive advantages through the further transfer of knowledge and technology. The negative effect of combining investment in R&D with a high intensity of backward integration most likely reflects the captivity of overly backward-integrated GVCs, where the focus is on maintaining and improving cost competitiveness rather than building innovation capabilities.

Figure 3 breaks down the above results for developed and developing countries. In both groups of countries, the effects work in the same direction as in the whole sample. We observe that the combination of high investment in R&D and low backward integration has the largest effect in developing countries. It follows that domestic investment in R&D increases the scope for transition to forward integration more in less developed parts of the world and in situations of lower dependence on imported values. In developed countries, the results can be explained by the fact that importing cheaper inputs helps these countries up to a certain point to participate in the international arena as value buyers in backward GVCs. However, at higher levels of this

integration, domestic innovation efforts and the backward integration seem to cancel each other out.

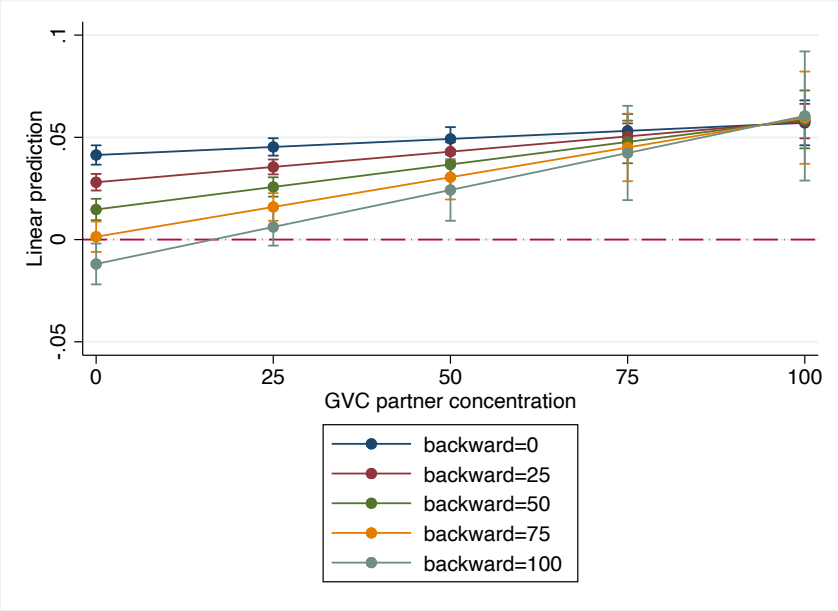
Figure 3: The moderating effects of domestic R&D expenditure and level of development



Source: Authors calculations

The upgrading may be constrained with power asymmetries and governance mechanisms within GVCs (Gereffi et al., 2005). Relationships which involve smaller number of partners are more prone to such outcomes due to power asymmetries and related differences in bargaining power of involved entities. In following step of investigation, we explore whether concentration on a smaller number of partners or having more diversified backward GVC partner network matters for the intensity of forward integration through value exporting. For this reason, we add to the usual measure of backward GVC integration, a Herfindhal-Hirschman measure of GVC partner concentration and introduce three way interaction between backward integration intensity, partner concentration and level of development of country. Accordingly, higher values of this variable reflect a country's integration into a smaller number of value chains, while the opposite holds for the case of smaller values of the coefficient.

Figure 4: The moderating effect of GVC partner concentration



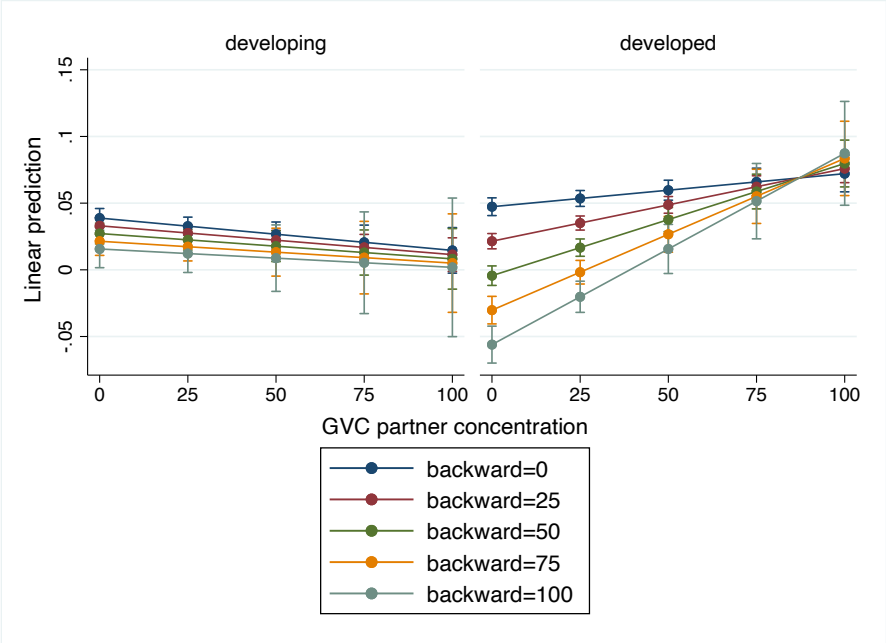
Source: Authors calculations

Results of investigation (Figure 4) offer interesting story. They show that diversified networks have strongest influence in situations when the intensity of backward integration is low, most likely reflecting the fact that entities at this level of integration are particularly sensitive to the risk of captivity. However, the forward integration in GVCs increases with rise in concentration of partners to the extent that at high levels of partner concentration the effect is significant, positive and of high magnitude regardless of the level of backward integration. Hence, rather than pointing to captive relationships this finding seems closer to arguments of SI literature (Lundvall and Johnson, 1994) about the beneficial effects of social relations for building of trust and commitment as preconditions for transfer of knowledge and technology. Concentrated networks in which partners have established trust and commitment may be more open to knowledge sharing but building of such relationships takes place over time.

The above results seem to be mainly due to developed economies (Figure 5), suggesting that greater reliance on a smaller number of partners increases trust and opens up the possibility of reallocating resources to more complex and demanding tasks at the upper levels of GVCs. In developing countries, the effect works in the opposite direction. At lower levels of backward integration, belonging to more diversified networks increases the intensity of forward integration, but this effect decreases afterwards. Moreover, at high values of this variable, the effect of partner concentration appears to be significant only for those with low levels of value-

importing integration, suggesting that in these contexts greater concentration leads to captivity within backward value chains.

Figure 5: The moderating effect of GVC partner concentration and level of development



Source: Authors calculations

As a final step we explore the relationship between backward and forward integration over time. It was previously noted that our findings reflect relationship between two GVC integration patterns measured at same points in time. However, learning is cumulative process that takes place over time with new knowledge building upon existing one. While in the short run backward integration may provide limited opportunities for upgrading through forward integration, over time accumulated capabilities can allow nations to make such shift. Our next part of analysis estimates effect of different lags of backward integration (Table 4) focusing on periods of up to 12 years in the past.

Table 4: Effects of backward GVC integration over time

Variables/lag of backward	t-1	t-3	t-5	t-8	t-10	t-12
backward	-0.0005*** (0.00004)	-0.0003*** (0.00004)	-0.0001 (0.00004)	0.0001 (0.00005)	0.0002*** (0.0001)	0.0002*** (0.0001)
R&D	0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.001)	0.005*** (0.001)	0.004*** (0.001)
institutions	0.01*** (0.008)	0.01*** (0.001)	0.01*** (0.001)	0.01*** (0.002)	0.01*** (0.002)	0.01*** (0.002)
Country	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Groups	2224	2223	2220	2217	2213	2208
Obs	30313	28375	26484	22712	18799	14925

Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors calculations

The results from Table 4 show that backward integration has a negative impact on forward integration in the short term, suggesting that the learning opportunities and skills acquired within this short period are not sufficient for the transition. This result could also be due to a reduced dependence of newcomers from developing countries in GVCs on exports of raw materials or a temporary loss of competitiveness of developed countries due to a redistribution of production to less developed GVC partners. Rodriguez-Clare (2010) and Tian et al. (2022) both find that developed countries can lose competitive advantages in the short term, only to regain them in later periods by reallocating resources to research and innovation. In the period between 3 and 8 years, the results show that there is no statistically significant relationship between the two patterns of integration. This finding could reflect a phase of accumulation of capabilities, in which the former dependence on exports of raw materials in developing countries is decreasing, but the conditions for the leap to a new integration pattern have not yet been reached. Finally, accumulated capabilities over a longer period of time seem to lead to a transition to higher forward integration.

A clearer picture of above effects emerges from subestimations on samples of developed and developing economies. In former we find negative and significant coefficient in t-1 period while findings for all other periods are not significant. A likely explanation is that meeting quality requirements and keeping pace with technological standards of GVCs requires learning. This forces value buyers in GVCs to invest in specialised production capabilities, a venture that is requirement of participation in GVCs but often takes place independent of support from partners at higher levels of GVC integration (Pietrobelli and Rabellotti, 2011). The time required to master these capabilities means that over short run transition of value chain

members from developed world towards imported intermediate inputs may cause temporary loss of competitiveness in their dominant, forward, integration pattern.

Table 5: Backward GVC effects over time in developed and developing countries

Variables/lag of backward	t-1	t-3	t-5	t-8	t-10	t-12
backward (developing)	-0.0005*** (0.0001)	-0.0002*** (0.0001)	0.00005 (0.0001)	0.0002*** (0.0001)	0.0003*** (0.0001)	0.0003*** (0.0001)
backward (developed)	-0.0002*** (0.0001)	-0.0001 (0.0001)	0.0001 (0.0001)	0.00004 (0.0001)	0.0001 (0.0001)	-0.00009 (0.0001)
Country	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Groups (developing)	1020	1020	1018	1017	1015	1012
Countries (developed)	12966	12172	11380	9798	8139	6485
Groups (developing)	1204	1203	1202	1200	1198	1196
Countries (developed)	17347	16203	15104	12914	10660	8440

Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels respectively.
Source: Authors calculations

Findings for developing economies are fully consistent with those for the entire sample. They support several stylised facts from the literature. First, it is evident that at lower levels of backward integration the intensity of value exporting through forward integration is also low (Mehta, 2022) due to either declining exports of raw materials or reallocation of resources towards mastering of production capabilities within the backward integration pattern (Tian et al., 2022). Second, our results correspond with theoretical models in which cumulative nature of learning and ceilings in upgrading through backward integration call for disconnection from existing value chains, development of domestic capabilities and, ultimately, reintegration in GVCs through different, forward, pattern (Lee et al., 2018, Lee, 2019).

6. Conclusions and implications

The countries of the world are constantly searching for new sources of efficiency that can be used in the process of upgrading and increased competitiveness. The international fragmentation of value chains has become one such source in recent decades, which can help countries access resources that are lacking in their home markets and compete more efficiently in the international arena. Participation in GVCs is attracting interest from both developed (Pleticha, 2021) and developing countries (Stollinger, 2016) as a source of efficiency, technology transfer and capability accumulation. Historical accounts of countries that have successfully transitioned from low to high income levels by taking advantage of GVC integration opportunities (Hobday, 1995) further fuel this interest. At the same time, questions about the feasibility and limitations of GVC-driven upgrading (Kummritz, 2016; McDermott

and Pietrobelli, 2017; Lee et al., 2018) and the risks of competitive deterioration (Antras, 2020) are raised, calling for research that sheds light on this process.

Within the above framework, the aim of our research was to explore an almost unaddressed topic in the GVC literature, namely the relationship between different GVC integration patterns. This largely neglected topic is particularly important for our understanding of the technological upgrading that takes place within GVCs. By answering the question of how nations move from one GVC integration pattern to another, what bottlenecks exist along the way, and what implications this has for their upgrading efforts, the study adds to academic knowledge about the dynamics of processes within global value chains, but more importantly, it provides guidance to anyone interested in exploiting opportunities and avoiding risks associated with GVCs. In this sense, our study has developed theoretical, practical and policy implications, which we discuss in turn.

6.1. Theoretical implications

From a theoretical point of view, our study offers a new perspective for the study of GVC-driven upgrading. There are studies that point to the upper limits of upgrading through backward integration (Lee et al., 2018; Ndubuisi and Owusu, 2021) and those that argue that rising to the top of the GVC ladder and mastering sophisticated and complex products and tasks requires forward integration (Lee, 2019) and even studies that examine the moderating effects of country development (Tian et al., 2022) on participation in GVCs, bottlenecks in the process of upgrading (Gereffi et al., 2005) and the role of home market conditions in the ability of nations to take advantage of GVC integration (Gereffi and Stollinger, 2013), but to date no theoretical framework or empirical analysis of the transition from one GVC integration pattern to another has been offered. This is surprising, as the literature has pointed out in several places that the backward GVCs offer upgrading opportunities only up to a certain point. After that, countries either revert to deeper integration in low value-added tasks and products or have to look for alternative ways of upgrading (Lee et al., 2018).

So far, only one study (Mehta, 2022) has discussed the issue and illustrated it using descriptive examples from different parts of the world. To address this gap, our study has developed a framework that argues that different GVC integration patterns provide different types of knowledge, each relevant to different stages of upgrading, and defines upgrading as a transition

from backward to forward integration. In addition, we argued that this process is moderated by the level of development of countries, the degree of concentration of the GVC network, home market conditions and the time spent accumulating capabilities. In this way, we were able to open the "black box" of GVC research and bridge two patterns of integration, a topic that had previously been almost completely ignored.

Our study complements two earlier, interconnected streams of GVC literature. On the one hand, we build on the stream of knowledge that argues that upgrading through GVCs requires nations to follow the in-out-in pattern (Lee et al., 2018) and build productive capacity by importing value before moving to the interaction between the domestic innovation system and the development of their own value export chains. On the other hand, our reasoning is close to the literature on innovation systems (Lundvall, 1992; Lundvall and Johnson, 1994; Pietrobelli and Rabellotti, 2011), according to which knowledge comes in different forms that require different types of activities to be absorbed. Both lines of thought indicate that behavioural patterns need to change during the upgrading process. Our study builds a new bridge between them by relating them to the process of transition from backward to forward GVC integration patterns.

6.2. Practical implications

The accumulation of capabilities is a cumulative learning process that requires functioning social relations, indigenous absorptive capacities and an efficient institutional framework that allows for technology transfer and knowledge flow. Historical accounts from different parts of the world (Hobday, 1995; Mehta, 2022) show that this process takes a considerable amount of time and can be influenced by a number of factors. As our research has shown, initial integration through the backward linkages reduces the incentives to forward integration, most likely due to embedding in the accumulation of production-related skills. Over time, these effects change to the positive, suggesting that the knowledge and skills acquired through backward integration eventually allow countries to move to the next stage of GVCs and build their own value chains. These results confirm the cumulative nature of upgrading (Carballa Smichowski et al., 2021), but also suggest the existence of catch-up cycles and an in-out-in pattern of integration as countries move up the GVC ladder (Lee and Malerba, 2017).

The research also points to differences in the effects between developed and developing economies, in terms of home market conditions and partner concentration. In particular, the results suggest that increasing integration has positive but diminishing effects in developing countries and diminishing and eventually negative effects in developed countries on forward integration. These results further confirm upper limits to learning through backward linkages and their negative impact on the core competitive advantages of developed economies. Moreover, our results show that home market conditions and partner network diversification matter most in situations where backward GVC intensity is low. Such weak relationships carry a higher risk of termination and captivity, and a supportive domestic environment and reduced reliance on individual sellers of value appear to facilitate the transition between GVC integration patterns.

Another practical implication that emerges from our findings concerns the threshold above which increasing intensity of value importation does not yield gains in terms of higher forward integration. Identifying such a threshold could help both policymakers and companies to manage their journey through GVCs more efficiently and reduce the risk of capture. The results of the research suggest that this threshold is between 50% and 60% for the share of foreign value added in domestic exports. Future analyses will have to show whether this ratio is indeed a threshold for moving to a different integration pattern or whether one falls into the trap of low value added and increased value import, but our results could be considered as a first step in this research direction.

6.3. Policy implications

Our findings offer several implications for policy makers and can help them make more informed decisions and improve their competitive position in the global economy. They highlight that the impact of backward on forward GVC integration varies over time. In the short term, it can have a negative effect that turns positive over a longer period of time. This suggests that policymakers should take a long-term perspective when assessing the benefits of GVC integration and allow time for initial challenges to turn into positive outcomes. Moreover, developing and developed countries may need different strategies when it comes to integrating and upgrading GVCs. In developing countries, the positive but diminishing effect of backward integration indicates the potential for technology transfer and capacity building. In contrast,

developed countries should be cautious about deepening their integration through backward linkages, as this could erode their competitive advantages in the long run.

Our findings suggest that countries with low levels of backward integration should prioritise domestic investment in research and development (R&D) and institutional quality. This can strengthen their efforts to position themselves as value-added exporters and help them catch up and compete effectively in global value chains. R&D investments should be aligned with their GVC integration goals. High levels of value-added imports can lead to diminishing returns on domestic R&D investments in terms of transitioning to alternative integration patterns. Policymakers should strike a balance between greater reliance on foreign value added and investment in R&D to maintain competitiveness. This underlines the need for careful resource allocation and strategic planning. For countries and firms that import limited value, diversifying their partner networks can reduce the risk of captivity and bottlenecks in the absorption of foreign knowledge and technology. At the same time, policymakers should recognise the strategic advantages of concentrated partner networks at higher levels of value integration, especially with regard to knowledge and technology transfer.

6.4. Limitations and future research directions

Researchers investigating the effects of GVC integration should consider the temporal dimension of this process in their analyses since our study revealed that the relationship between backward and forward GVCs may vary over time. Incorporating long-term perspectives and dynamic modelling in empirical studies can yield more accurate insights into the evolving nature of this relationship. Empirical research should distinguish between developing and developed countries when assessing the impact of GVC integration. Comparative studies that account for these differences can provide valuable empirical insights into how economic development levels influence the relationship between GVC integration patterns. Analyses should attempt to assess the types of activities undertaken within specific GVC regimes, rather than focusing only on value-added measures. Future investigations should also aim to quantify the ceilings of backward integration in order to help more efficient design and implementation of GVC policies. Our investigation pointed to the relevance of home market innovation investment. Future studies should explore moderating effects of other dimensions of institutional environment. Finally, cross-country GVC studies are scarce with

industry level data. Subject to data availability future studies should assess the validity of our findings in models enriched with additional sets of control variables.

Appendix

Table A1: Correlation matrix

	forward	backward	R&D	institutions	concentration
forward	1.00				
backward	-0.05***	1.00			
R&D	0.18***	-0.01***	1.00		
institutions	0.08***	0.11***	0.59***	1.00	
concentration	-0.05***	0.04***	0.09***	0.41***	1.00

Note: ***,** and * denote statistical significance at 1%, 5% and 10% levels of confidence

Table A2: Factor analysis results on institutional variables

Variables	Factor loadings
Voice and accountability	0.866
Political stability	0.823
Government efficiency	0.967
Regulatory quality	0.957
Rule of law	0.982
Perception of corruption	0.968
Kaiser-Meyer-Olkin measure of sampling adequacy	0.918
Bartlett test of sphericity p-value	0.000
Cumulative explained variance	0.863

Table A3: Variance inflation factors

variable	VIF
backward	1.05
R&D	1.65
institutions	2.00
concentration	1.25
Mean VIF	1.49